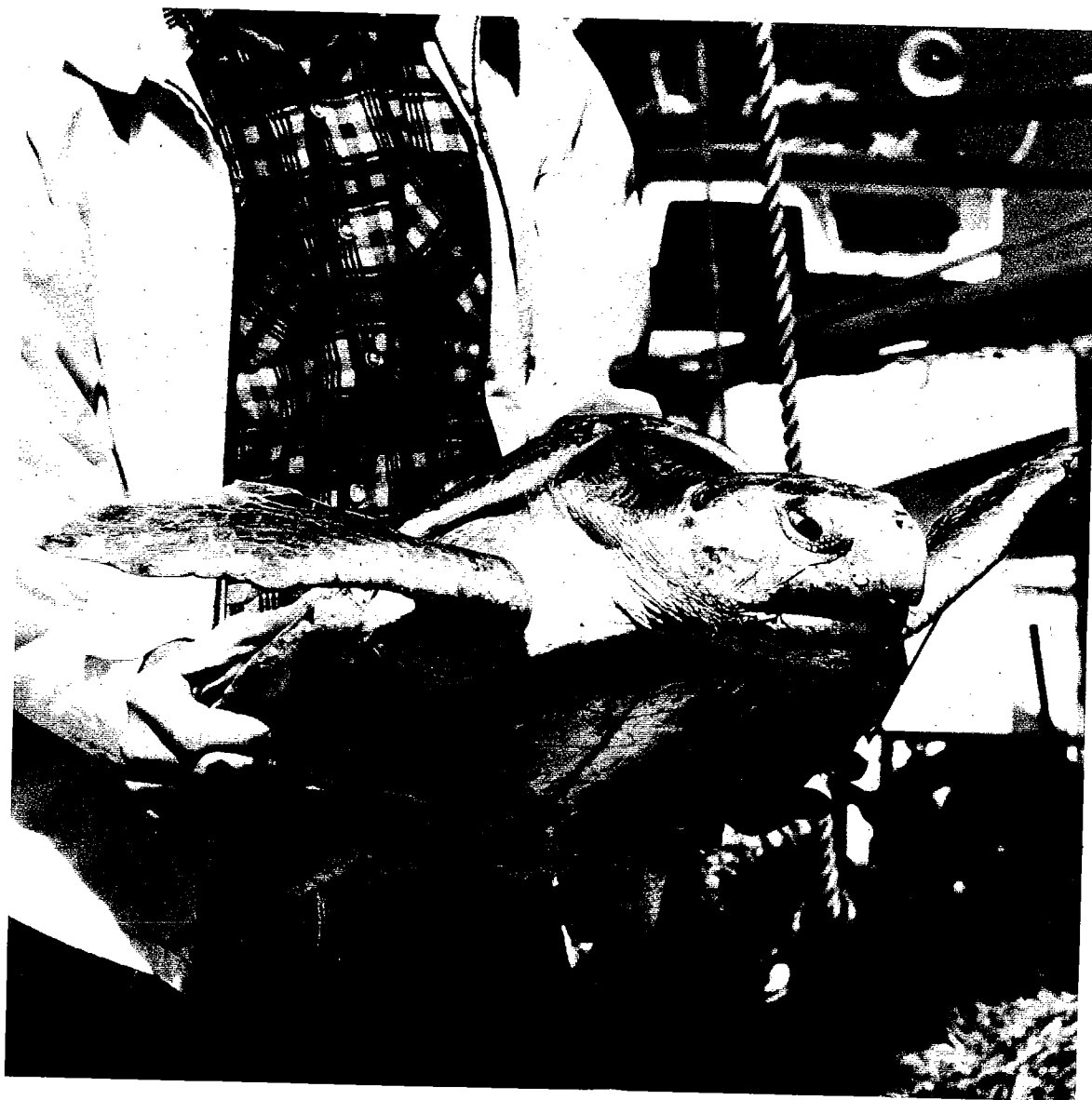




# Marine Fisheries REVIEW

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*Headstarting Marine Turtles*

# Marine Fisheries REVIEW



On the cover: A young Atlantic ridley, *Lepidochelys kempi*. Photograph by Larry H. Ogren.

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# Radio Tracking Juvenile Marine Turtles

ROBERT E. TIMKO and DAVID DeBLANC

## Introduction

Five species of sea turtles are indigenous to the Caribbean and the Gulf of Mexico. For a variety of reasons, they are all in relative danger of extinction and, as such, are protected by the provisions of the Endangered Species Act of 1973. Reasons for the population decline are: Commercial exploitation for meat, eggs, and shells; habitat destruction by man; natural predation; and incidental capture in fishing trawls.

One approach being evaluated to replenish stocks of marine turtles is called "head starting." The rationale behind head-start programs is to reduce high hatchling mortality rates experienced in wild turtle populations by rearing turtles in captivity to an age when mortality is significantly reduced. A head-start program for the Atlantic ridley, *Lepidochelys kempi*, was initiated jointly by the United States and Mexico in 1978. In this program, eggs are collected from nesting grounds near Rancho Nuevo, Tamaulipas, Mexico, for incubation and hatching. To allow for possible imprinting for future nesting migrations, the newly hatched turtles are permitted to enter the water at these locations. There the hatchlings are collected and transported to the Galveston (Tex.) Laboratory of the National Marine Fisheries Service's Southeast Fisheries Center (SEFC),

where they are raised in a protected environment. The young turtles are released in known habitats of juvenile turtles, such as the lower Gulf of Mexico or off the west coast of Florida.

The first few months after release are critical for head-started turtles, as they must adapt to the natural environment. Thus, information on the activity of the turtles during this period will aid in evaluating the initial success or failure of the release. One technique to acquire information is radio tracking.

A radio-tracking system was developed by the SEFC's National Fisheries Engineering Laboratory, NSTL Station, Miss., for head-started turtles. The goal was to develop a system to provide reliable information concerning movement and behavior patterns of juvenile turtles.

Specific steps for developing a radio-tracking system included a review of past problems associated with radio-tracking experiments, development of an improved radio-transmitter package design, demonstration that the transmitter did not interfere with normal turtle activities, and a demonstration that the system was suitable for short-term (30 days) tracking experiments.

## Preliminary Study

Movements of several juvenile loggerheads were monitored for over a week. Each turtle was tagged with a miniature pulsed radio frequency transmitter sealed in hollow plastic cork. The corks were attached to the trailing edge of each turtle's carapace

with a length of braided linen line equal in length to the turtle's carapace. The transmitters were tracked in a light aircraft using standard radio direction-finding techniques. Even though the approach was successful, several problems were noted:

1) Several transmitters broke away from the turtles due to failure of the attachment lanyard. The detachment problem was due presumably to abrasion of the linen lanyard by the edge of the carapace. A more durable material would need to be identified for the attachment lanyard.

2) A transmitter malfunctioned for unknown reasons. This malfunction was believed due to saltwater incursion, dictating the need for better package sealing.

3) Transmitter damage was caused by the turtles biting them. This damage could be prevented only by making the attachment lanyard substantially shorter than the carapace length. Shortening of the lanyard, however, somewhat defeats the purpose of the lanyard approach, which is to provide antenna exposure above the water surface even when the turtle has not fully surfaced. It was not felt that a satisfactory solution to this problem existed, but the effects could be minimized.

4) There was a lack of sufficient radio tracking range. The transmitter range limitation was due to the low output power from the transmitter imposed by state-of-the-art of transmitter miniaturization, to state-of-the-art receiver limitations, and to the size package a juvenile turtle could be expected to carry. Use of a higher gain, more directional antenna, and improvements in receiver performance could increase the transmitter range.

5) There was a lack of adequate aircraft search range. The use of a larger, twin-engine aircraft would extend the range of search coverage, thereby eliminating this problem.

## System Description

The final tracking system selected was comprised of a small transmitter

**ABSTRACT** — A "head-starting" program for aiding the population recovery of endangered marine turtles has been evaluated by the use of radio tracking. Tracking hardware, aircraft installation, and procedures are described.

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float towed by the turtle and a tracking receiver, antenna system, and Loran-C navigation receiver installed in tracking aircraft.

### Transmitter

Based in part on the previous juvenile turtle tracking work, commercially available transmitters, from Wildlife Materials, Inc.<sup>1</sup>, were selected for use. Criteria used for selection of the transmitters were output power, battery life, size, and weight.

Before release, behavior studies were conducted on the amount of time tagged and untagged juvenile Atlantic Ridley turtles spent beneath the surface of water in 200-liter tanks. Also observed were the number of dives and the number of times the turtles were successful in capturing live prey (shrimp and minnows). These studies failed to show any statistically significant difference in behavior between tagged and untagged turtles. Also, the attachment lanyards that were slightly shorter than the carapace of the turtle were optimum for maximizing exposure time of the antennas, and at the same time, avoiding bite damage by the tagged animal. The turtles to be tracked were expected to weigh approximately 484 g when released.

Considerable effort was expended to improve hydrodynamic characteristics of the transmitter float. Principal shortcomings of previous designs related to the amount of drag evident to the tagged animal and a characteristic tilting of the antenna when the turtle swam. A variety of float models were constructed and evaluated in a hydrodynamic flow tank. These included hemispheres, sections of ellipses, several boat shapes made from two sections of hemispheres, ellipses, and several triangular shapes. Attachment points and weight distributions were varied. The shape selected from this evaluation was the triangular pyramid (Fig. 1). This design provided good under-

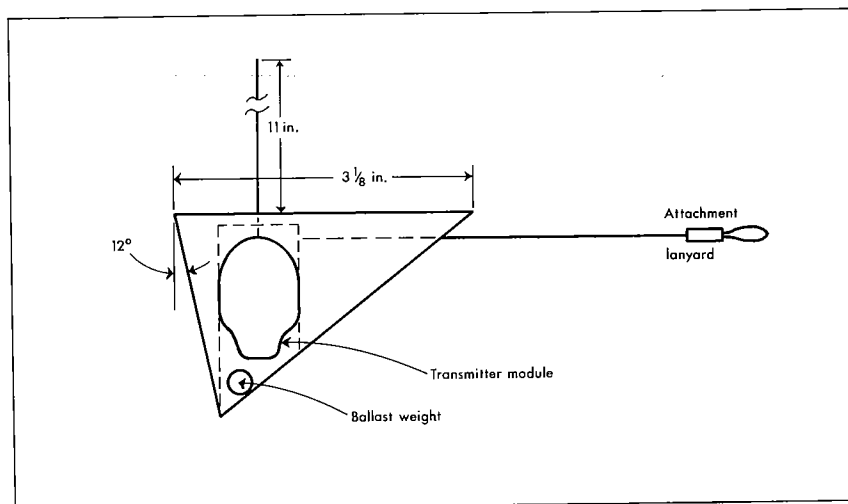


Figure 1.—Transmitter package assembly.



Figure 2.—Juvenile turtle with radio transmitter float.

water stability, minimal drag (most of the other shapes tumbled and twisted when towed) and it maintained the antenna in a vertical position even when towed with the antenna partly submerged.

The transmitter module, as received from the manufacturer, is an oblong blob weighing 8 g. It consisted of a hermetically sealed transmitter with two mercury battery cells encapsulated in an acrylic plastic. This

module was then installed in the triangular pyramidal float and sealed with silicone rubber. This assembly (shown attached to a turtle in Fig. 2) had a total weight of 28 g. The transmitter radio frequency power output in saltwater was averaged -7 dbm with a capability of 45 days of continuous operation. On-off control was provided by a normally closed reed switch held off by a magnet taped to the top of the transmitter.

<sup>1</sup>Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Attachment to the edge of the turtle's shell was made with a No. 6 stainless steel wire. Sixty pound test monofilament nylon was later found to be a better choice because of problems with corrosion or fatigue of the stainless steel.

### Receivers

The tracking receiver was purchased from the same manufacturer as the transmitter. This receiver has an exceptionally high-gain (130 dB), low-noise performance, enabling it to receive very weak signals. The receiver is battery operated and, thus, was independent of the aircraft power system. Tuning the receiver to enable it to receive the signals from different transmitters was done via digital thumbwheel switches. This was an extremely worthwhile feature for aircraft operation since it was necessary to track many transmitters simultaneously.

### Antenna System

The most critical part of the tracking system, particularly when tracking these extremely low power transmitters, is the antenna installation. Slight changes in antenna mounting can produce great variations in system sensitivity and tracking range. Because of the requirements of area tracking coverage, a small twin engine aircraft was necessary. Unfortunately, all small twins that were available for lease were of the low-wing design. This posed severe problems in antenna mounting.

The commercially available tracking antennas are all variations of yagi antennas. They provide a good trade-off between simplicity of construction, durability, and sensitivity. The model selected for our experiment was a 3-element yagi. The longest rear element was 36" long and the boom was 42" long. This was a vertically polarized antenna, and to receive the vertically polarized transmitted signal, it needed to be mounted vertically. This was a physical impossibility on the low-wing aircraft.

The resulting installation for the first experiment was to mount the

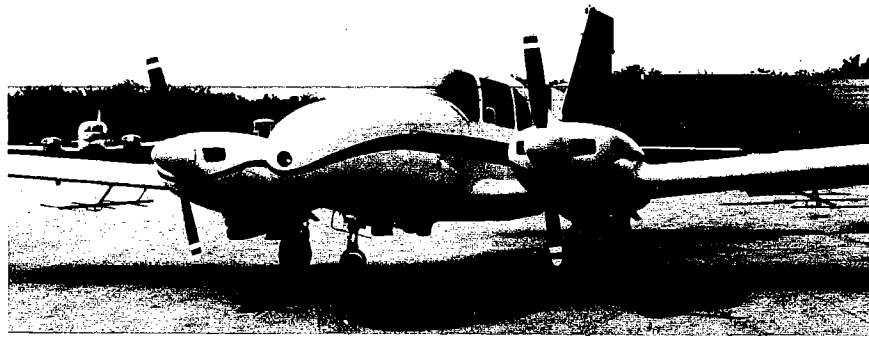


Figure 3.—Tracking aircraft.

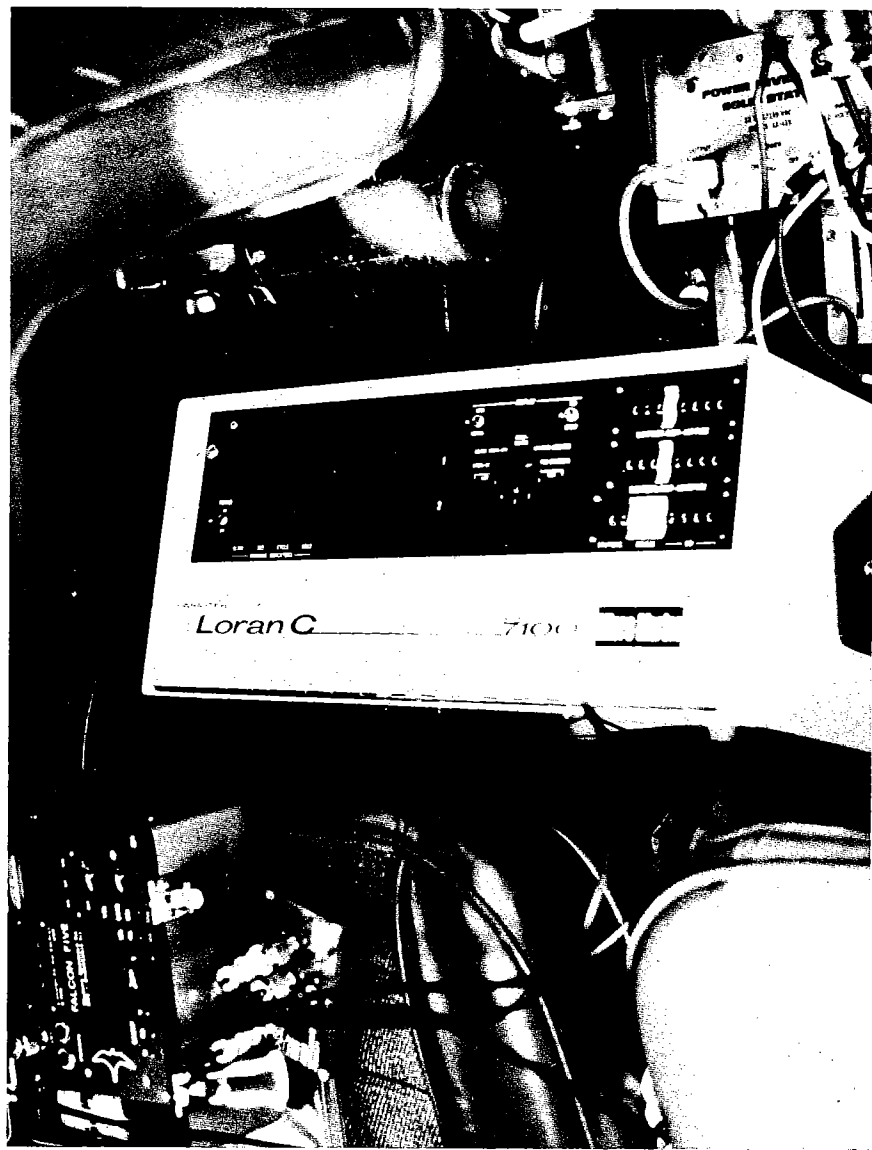


Figure 4.—Aircraft interior equipment installation.

antennas horizontally, one on each wing with the sensitive axis directed toward the wingtip. They were connected to the receiver with a two-position selector switchbox. Although this worked, it yielded a tracking range of only about 7 miles. This configuration is shown in Figure 3.

Measurements in the lab indicated that there is about 12 dB reduction in gain with the antennas mounted in the horizontal versus the vertical orientation. Since the antenna gain is only about 8 dB to begin with, this meant that the horizontal performance was 4 dB down from a simple dipole. So, for a second experiment, a quarter-wave whip antenna was added to the belly of the aircraft and selected by a third position on the switchbox. This increased the tracking range to 30 miles — much more than the 4 dB difference theoretically indicated. The mode of operation, since the whip was not directional, was to make the original detection with the whip and then switch to the yagis for direction finding.

### Aircraft Navigation

Aircraft position information was obtained with Loran-C receiver (Micro-Marine Model 7100). The receiver automatically displays latitude and longitude, measures 19" x 10", and weighs 33 pounds. It was mounted to seat rails in the aircraft after the spare seat had been removed (Fig. 4). Power (115 V) for the unit was provided through a 300 W inverter from the aircraft's 12 V electrical system. The aircraft's ADF antenna was used for the system and was found to provide an adequate signal for operation in relatively remote areas where the turtles were released. Some interference was noted, however, in areas of electrical activity, such as near power sources and major airports.

### Florida Bay Experiment

The first experiment was conducted in western Florida Bay in the vicinity of the Everglades. Two groups of six radio transmitter-tagged turtles were

released.

The first group of turtles was released on 28 February 1979. Their transmitters were provided by two commercial manufacturers. All three of the transmitters from one supplier failed shortly after release. The three transmitters from Wildlife Materials, Inc., were tracked for 9 days, and then were recovered by boat after having broken loose from the turtles. Separation was due to fatigue or corrosion of the stainless steel leader at the reinforcing ferrule in the balsa wood float. During the 9-day tracking period, there was an absence of any interruption in the transmitter signals, which, if present, would have indicated that the turtle was diving. It was impossible to determine exactly when the transmitters detached, but it was generally agreed that detachment occurred shortly after release.

The second group of turtles was released on 6 March 1979, in the vicinity of Sandy Key. As in the earlier experiment, six radio-tagged turtles were released. All transmitters were from Wildlife Materials, Inc. The turtles spent most of the time submerged, with only brief periods at the surface. This made tracking difficult because transmitter contact could only be maintained for a few moments. Each day, approximately three turtles were located, but different individuals would comprise the group. After a 6-day tracking period, the turtles were within 10 miles of the release point. A boat, equipped with a hand-held tracking receiver, was dispatched to verify that the transmitters were still attached to the turtles. This verification was made for one turtle that was kept in visual contact for approximately 1 hour. The turtle appeared to be acting normally.

### Homosassa Experiment

The second field experiment was conducted in the Gulf of Mexico adjacent to Homosassa, Fla. To minimize flying time and extend the tracking period, all of the instrumented turtles were released in one group. This was done just offshore from Chassahowitzka Point on

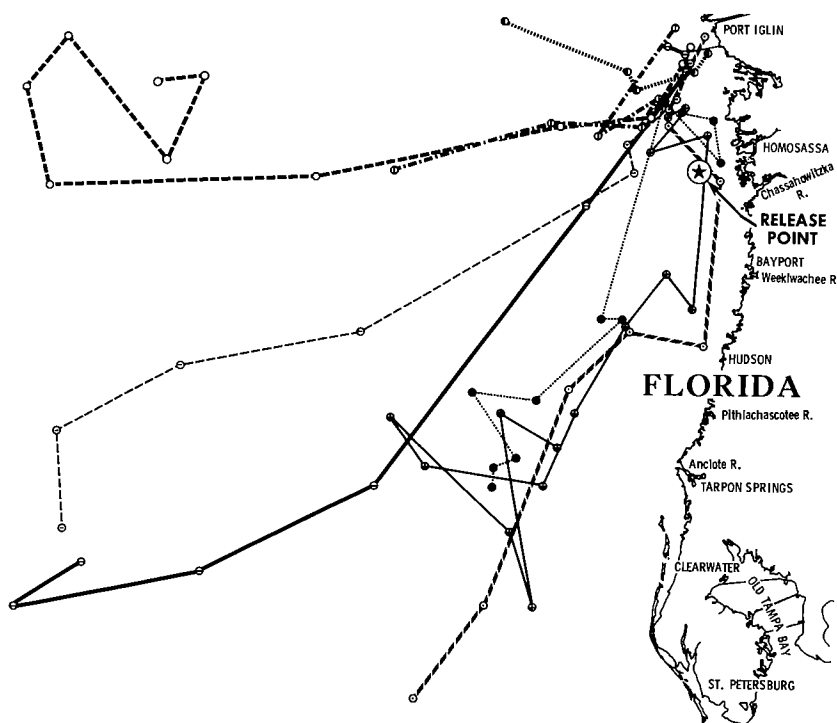


Figure 5.—Turtle tracking data.

8 May 1979, when 10 radio-tagged turtles were released with about 1,500 other turtles. Aircraft tracking was conducted daily for the first 10 days, and then for 3 days to conserve aircraft time and provide relief for tracking personnel. Tracking resumed on an alternate day schedule with 4 of the original 10 turtles being tracked until the 21st day after release. At this time a 1-week break was taken. Tracking resumed 30 days after release with only two of the turtles being located. A vessel was dispatched to verify the attachment of the transmitter to one of the turtles. The transmitter was recovered without being attached to the turtle. Detachment was caused by a broken attachment lanyard. Detachment apparently occurred just before recovery since signals were continuous on the day the transmitter was retrieved, and intermittent on the previous day, indicating that it was attached to a diving animal.

A second vessel was dispatched to locate and verify attachment of the sec-

ond transmitter; however, verification was not possible due to behavior of the animal. Apparently, the turtle had become sensitive to noise and would dive when approached by the vessels or the search aircraft at low altitudes. This made it impossible to precisely locate the animal. Tracking data from this release are given in Figure 5. The points shown are the aircraft-determined locations at various intervals averaging about every third day. During the 30-day tracking period, some of the animals ranged to a distance of 150 miles offshore.

### Results and Conclusions

The experiments were successful in meeting most of the major objectives. Most problems observed with previous tracking attempts were solved. Premature detachment of the transmitter module was a problem with the stainless steel attachment leader. This was solved with the use of monofilament nylon. There was no

evidence of detachment with the nylon lanyard.

A remaining problem is with the transmitter package design, which allows the turtle to reach the antenna tip and bite it, causing a pigtail curl in the tip. Fortunately, this had no detrimental effect on transmitter range.

The most significant remaining problem is the limited tracking range due to the receiver antenna mounting on the aircraft. Because most experiments probably will rely on leased aircraft, an antenna system that will mount on any type of aircraft would be desirable.

### Acknowledgment

The author gratefully acknowledges James P. McVey, SEFC, Galveston Laboratory, for providing biological consultation and turtles.

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## NOAA/NMFS Developments

### National Climate Plan Published by NOAA

A 5-year plan to reduce the adverse effect of climatic conditions on the economy and environment, including fisheries, has been released by the Commerce Department's National Oceanic and Atmospheric Administration (NOAA). Prepared by the National Climate Program Office, the plan's goal is to help avert weather-related problems such as food and fuel shortages through improved forecasting and more efficient dissemination of climatic data.

Funds will be drawn from appropriations 11 of the 17 participating agencies receive for climate-related activities. The proposed 1981 budget is \$126.7 million. Specific goals of the

plan include:

- 1) Insuring that industries such as farming, construction, recreation, shipping, and fishing receive improved climatic data and use it more effectively;
- 2) Assessing the effect of increased carbon dioxide on the climate;
- 3) Studying the extent to which solar and earth radiation modify climatic conditions, and
- 4) Gathering more data on the oceans' roles in climate formation.

Edward Epstein of NOAA is director of the National Climate Program. Participating in the project are 11 Federal departments, the Agency for International Development, Council

on Environmental Quality, National Aeronautics and Space Administration, National Science Foundation, the Environmental Protection Agency, and the Federal Emergency Management Agency. Copies of the plan may be obtained from NOAA's Environmental Science Information Center, 6009 Executive Boulevard, Rockville, MD 20852.

### Tagged Albacore Taken Off Hakalau, Hawaii

The first recapture in Hawaiian waters of an albacore caught and tagged off San Diego, Calif., over 2 years ago, has been reported by Richard S. Shomura, Director of the Southwest Fisheries Center's Honolulu Laboratory. According to Howard Takata, the University of Hawaii Sea Grant's Marine Advisory Specialist stationed in Hilo who made arrangements for the return of the tag, the fish was one of nine albacore

caught off Hakalau, Hawaii, by Marlon Pacheco fishing from his boat, the *Dawn L* on 15 October.

Fishery scientists at the Southwest Fisheries Center's La Jolla Laboratory in California have been routinely tagging albacore in California waters for a number of years. To date, 25-30 of these tagged fish have been recaptured by Japanese longliners in the North Pacific. About a dozen tagged fish have been taken in Hawaiian waters but Pacheco's fish is the first tagged albacore caught in the local "ika-sibi" fishery.

Pacheco's albacore was first caught on 25 July 1978 south of San Diego at lat. 31°31'N, long. 118°33'W by a California baitboat (pole-and-line fishing boat). The fish was 32 inches (81 cm) long (fork length) and weighed 26 pounds (12 kg) when tagged and was about 41 inches (106 cm) long and weighed 54 pounds (24 kg) when caught by Pacheco. The straight line distance from the point it was tagged and released to where it was recaptured off Hakalau is approximately 2,100 nautical miles. Since albacore are known to make transpacific migrations between the U.S. west coast and Japan, Shomura speculated that this fish may have made a crossing from California waters to Japan before arriving in Hawaii during the approximately 27 months it was at liberty.

Pacheco received a \$2.00 reward rather than a \$50.00 reward which was contingent on the return of the fish's head. The value of the head of this particular fish lay in the fact that the fish was one of many, at the time of release, that had been injected with the antibiotic tetracycline for age and growth studies. The tetracycline injection produces a mark on the fish's otoliths (ear bones) which is used as a reference point to count the growth rings.

Because fishery scientists are continuing to tag and release albacore not only off California but also off Japan, local fishermen are urged to carefully examine their catches for tags. Fishery scientists at the La Jolla Laboratory use a red tag to identify fish injected with tetracycline. Infor-

mation obtained from these tagging experiments provide much vital information on the life history of these valuable commercial fishes, said Shomura.

## **Marine Fish May Use Tiny "Magnets" to Navigate**

Preliminary results of research on tunas and green turtles indicate that small "biological magnets" in the frontal part of the skull may help explain the species' remarkable navigation abilities, reports Richard S. Shomura, Director of the NMFS Southwest Fisheries Center's Honolulu Laboratory. The research is being conducted by University of Hawaii graduate students Michael Walker and Anjanette Perry together with Andrew E. Dizon of the Honolulu Laboratory and J. Kirschvink of Princeton University.

The mystery of how migratory animals can navigate accurately over great distances has long puzzled biologists. Studies on the navigation of migratory birds and homing pigeons, however, have revealed a surprising ability of these birds to sense the geomagnetic field of the Earth and to use it to guide their travels. This geomagnetic "map" seems to be accurate to within about 5 km (3 miles) over most of the Earth's surface and hence may be one of their most important sensory tools.

When these magnetic effects were discovered, no plausible mechanism through which animals might detect and use the weak geomagnetic field was known. Recently, however, a surprising variety of animals including bacteria, honeybees, pigeons, and dolphins have been shown to synthesize small crystals of magnetite or lodestone, a mineral containing iron. The tiny, iron-rich particles in the body of the animals act like simple compass needles in the Earth's magnetic field and may be the key to the sensory mechanism which guides the animal's incredible migratory behavior.

Using the paleomagnetic facilities at the Hawaii Institute of Geophysics,

including an ultrasensitive magnetometer utilizing a liquid helium temperature device which can detect the presence of microscopic amounts of magnetite anywhere in a tissue sample, Walker, Perry, Dizon, and Kirschvink recently conducted a joint search for similar magnetic crystals in migratory Pacific tunas and green turtles. They used nonmagnetic dissecting tools such as plastic picnic knives and shards of glass and found tens of millions of magnetic crystals in the head of these animals — enough material to provide tunas and turtles with an extremely accurate magnetic map sense. In the tunas (yellowfin, skipjack, and kawakawa) the magnetic material was very precisely and repeatedly isolated in or upon the frontal bone of the skull, said Dizon.

This discovery of the small biological magnets suggests that a magnetic sense ought to be looked for in animals. In experiments conducted at the Kewalo Research Facility, Walker and Dizon have already discovered an unconditioned magnetic response in yellowfin tuna, and Perry is experimenting to see if such a response can be detected in green turtle hatchlings. Detailed Pacific-wide data on magnetic lineations on the sea floor and magnetic storms produced by solar winds are available, and it would be interesting to determine whether these magnetic parameters influence the migratory patterns of marine animals, said Shomura. If these migratory patterns of marine animals are indeed correlated with these magnetic parameters, these studies could be of great value in predicting the distribution and movements of commercially important fishes such as the tunas, concluded Shomura.

These experiments to detect unconditioned magnetic responses in marine animals are but a few of the many important research activities that are continuing at the Kewalo Research Facility. Past research at the facility has not only provided new scientific data on the behavior and physiology of the tunas but has also provided much practical aid to the local fishing industry, said Shomura.